Practical Limits to Atmospheric Mesoscale Predictability

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LONG-TERM GOALS

The long term goal of this project is to determine the mesoscale atmospheric predictability and how it relates to synoptic scale uncertainty due to sampling and data assimilation of incomplete samples on the larger scale.

OBJECTIVES

The objectives of this research are to determine the ability to numerically predict mesoscale coastal structures in a variety of synoptic scale situations and demonstrate for given small scale structures the time ranges under which they might be considered predictable. The answer is probably dependent on the data assimilation system and one objective is to determine this sensitivity.

APPROACH

The basic approach is to run a series of numerical model experiments using different data assimilation methods and the same observational samples and determine the relative spread in mesoscale forecasts. The operational multivariate optimum interpolation (MVOI) system for the COAMPS model and the multiquadric interpolation (MQ) system are used to define the initial conditions for the COAMPS model. Forecasts out through 36 hours were then made on nests down to 9km resolution and diagnostics were applied to determine the impact that the data assimilation system had on the subsequent evolution of a synoptic-scale low pressure system and its associated mesoscale structure.

In addition, studies of mesoscale error growth are being carried out using routine mesoscale forecasts with the MM5 model run at NPS. These forecasts are used to determine error characteristics on the 12km grid and relate them to things such as the synoptic-scale flow pattern and flow direction relative to topography.

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WORK COMPLETED

During the past year, a case of explosive cyclogenesis that occurred off the coast of California was used to examine the impact of data assimilation technique on the evolution of the synoptic and mesoscale structures. The case occurred on Feb. 12-13, 2001 during the Pacific Landfalling Jets Experiment (PACJET) and had dropsonde and aircraft observations available in addition to the routine observations. Model simulations have been run for this case using both the MVOI and MQ where observations have been included and excluded (first guess only). These model simulations have been compared to determine the evolution differences and their dynamic causes. The two data assimilation approaches differ in both the mathematical technique to define the structure but also the MQ approach undergoes a divergence removal step prior to insertion into the model. The results were presented at the Mountain Meteorology conference in June 2002.

In addition to the study of data assimilation impacts, a study was begun to examine the growth of mesoscale error in real-time forecasts using the MM5 model run at NPS. The study is not yet complete but model forecasts made routinely twice a day at NPS have been collected between April and September 2002 and reformatted in order to calculate the spread in lagged forecasts. While not ideal to determine mesoscale error, this study does allow the determination of mesoscale error growth due to synoptic scale differences. The data has been processed and a student, Jodi Beattie, is relating these error statistics to the synoptic-scale pattern and other factors.

RESULTS

The results of the study utilizing different data assimilation systems show that the characteristics of the analysis are important to the subsequent cyclone evolution. The cyclone forecasts were very different in both intensity and structure using the MVOI and MQ data assimilation systems. For this case the MVOI produced a stronger cyclone (closer to the actual cyclone) than the MQ and there were rather large differences in the mesoscale precipitation fields. The primary cause of these differences was the impact of the initial divergence in the MVOI analysis to favorably spin up the cyclone. The lack of this divergence in the MQ case slowed the initial development of the cyclone. While this difference was favorable in the cyclone off the California coast, a cyclone system over the central Pacific was poorly forecast by the MVOI system due to incorrectly analyzed divergence. The MQ system did better with this system as the divergence was allowed to spin-up in a consistent manner. The main conclusion from this study to date is that there are differences in the way the two data assimilation systems handle divergence and whether a given system handles it better depends upon the consistency with the other dynamics. Arguments can be made for both approaches with neither being definitely better.

The study examining the growth of mesoscale error is not complete but preliminary results show that there is a strong relationship between the synoptic-scale flow pattern and the spread in mesoscale forecasts. The largest mesoscale spread tends to occur near topography when the flow is directed across the topography. This suggests an important source of mesoscale error similar to that identified by our study of a landfalling front in previous years. The other result to date is that the mesoscale forecast spread does undergo an initial decrease and then increase due to the model spin-up time when mesoscale structures are being excited from the synoptic scale fields used to initialize the model.

IMPACT/APPLICATION

The impact of these studies will be in furthering our understanding of the limits to mesoscale prediction using actual numerical models and data assimilation approaches. This will greatly aid Navy forecasters in knowing how best to use forecasts from mesoscale models.

TRANSITIONS

These results have been used as classroom examples at the Naval Postgraduate School.

SUMMARY

This research has demonstrated that numerical weather forecasts on small scales are very sensitive to small differences in the analyzed structure of the atmosphere used to make the forecast. The role of the data assimilation system in exciting errors has been examined for one case will be further tested in other cases. This exact nature of the mesoscale forecast sensitivity and its dependence on weather regime is being determined in the ongoing research.

PUBLICATIONS

Nuss, W.A. and D.K. Miller, 2002: Landfalling cyclone forecast sensitivity to varying data assimilation methods in a mesoscale model. *Preprints of 10th Conference on Mountain Meteorology,* Park City, UT, June 17-21, 2002